Rec'd PCT/PTO 18 MAY 2005
10/535359

HYDRAULIC WHEEL

Technical field of the invention

The present invention relates to a device which uses the potential and kinetic energy of water from waterways or tides in order to convert it into electricity.

Prior Art

The wheels currently in existence, for using the energy of water in the natural direction of the current, are wheels referred to as wheels having blades constituted by blades of a constant thickness against which the water presses and which are assembled on a rotating frame which is generally constituted by two parallel discs at the ends of the blades; these wheels substantially use the dynamic energy of the water. Various types of bladed wheel have been produced, referred to as top, side and bottom types, etcetera, the most efficient being the Sagebien water wheel which was invented in the nineteenth century; the use of bladed wheels was then significantly reduced since no bladed wheel was able to harness the potential energy of water levels.

They were practically replaced in the nineteenth century by turbines having a much faster flow and rotation rate with a flow of water which was significantly modified and constrained by the machine (Francis-Kaplan turbine etcetera), which turbines allow the potential energy of water levels to be harnessed to the greatest possible extent.

New wheels appeared which themselves form a dam for the water by means of their axle which is constituted by a rotating cylinder, but the introduction of the blades into the water, owing to the fact that they are connected to the cylinder, brings about stresses which impair the flow and the geometry of the assembly; these wheels allow the water to pass in a stationary state.

The present turbine operates based on a new type of bladed wheel referred to as a bladed dam type wheel which allows a fixed dam to be integrated in the wheel for the first time and, in this manner, allows all the potential of the water level to be harnessed in addition to the kinetic energy of the traditional bladed wheels, with no constraint being placed on the natural

flow; the only losses are the leakage rate losses which are linked to the precision of the production operation and which are in this case minimised to the level of the clearances of the blades in the water discharge and supply channel.

Description

The present invention relates to a bladed wheel which uses the potential and dynamic energy of water from waterways or tides in order to convert it into mechanical energy which can be converted into electricity; it comprises:

- a rotating movable part which is referred to as a rotor (1) and which is constituted by blades (2) which rotate about a horizontal axle (6) and which are assembled at the ends thereof by means of circular discs (3) and (5),
- a fixed part (4) which serves as the dam which is required for retaining the water level,
- a water inlet channel (15) and a water outlet channel (16).

The novelty is constituted by the cylindrical crown shape of the movable part (1) which makes it possible, in the space left free by the movement thereof, to produce the element (4) for retaining the water; the inlet channel (15) is dimensioned and is an integral part of the device; owing to the natural flow of water with no constraints, the whole allows the highest yields at low water retention levels; use is made of the kinetic energy of the water in the upstream descending portion from A to B and, during the transition C from upstream to downstream pressure, the potential energy of the water level.

The only losses are the leakage rate losses which are linked to the precision of the production operation and which are in this case minimised; the fixed dam part (4) further allows the speed multiplication devices (10) to be accommodated which are required for driving the electrical generators, thus reducing the external arrangements which are generally reserved for this purpose.

In order to obtain a good understanding of the invention, a first embodiment is described below with reference to Figures 1 and 2.

The device according to Figure 1 comprises a rotating part (1) which is constituted by an assembly of blades (2) which are carried at one of the ends thereof by an outer disc (5); the example comprises 24 blades but the number thereof may vary in accordance with the diameter of the wheel and the length thereof, the arrangement being connected to the flow rates and the levels of water to be processed, and it is this assembly (1) which can be moved about the axle (6); the trajectory (7) of the blades (2) uses only a limited outer space and thus leaves the inner space entirely free in which the fixed part (4) which serves as a dam for retaining the water is located. Intermediate support discs (5) may be required in accordance with the spans of the blades, these crown discs (5) are recessed in the central portion thereof and have no axle, a solid disc at the other end of the blades transmits the energy to the rotation axle and the extent of rotating movement is thus limited only to the outer envelope of a cylinder having a thickness which is directly derived only from the volumetric spatial requirement of the blades in space and the solid disc.

The outer disc (5) can be moved on the fixed cylindrical part (8) which serves as a guiding and travel path, the contact being brought about by a number of rollers (9) which can vary in accordance with the diameters and the forces to be transmitted.

The blades (2) have a hydrodynamic shape in order, on the one hand, to provide sufficient rigidity for their mechanical strength and, on the other hand, owing to the inclination thereof which can be very variable, to allow them to limit the negative effects during their introduction into and movement in the water as far as the inlet (15).

The position of the axle (6) located in the dam for retaining water allows the blades to enter the water in a position having the minimum of resistance and, as soon as they enter the water, allows them to be driven by the current of water produced by the machine in the channel (15).

According to Figure 2: the space which is not harnessed by the circular movement of the rotor (1) which supports the blades (2) allows the fixed part (4) to be integrated which forms the fixed dam for retaining the water, leaving passage for the blades only in the lower portion.

This dam itself, owing to the low geometric shape thereof, constitutes the water outlet channel which is adapted to the flow rates of each structure. The assembly is connected to vertical concrete walls (14) which serve to laterally retain the earth.

The geometry of these dams (4) having a metal framework, which geometry is brought about because of the mechanical strength thereof, allows belt or gear type speed multiplication devices (10) to be incorporated therein which are required for the electrical production of the generators, thus converting the assembly into a hydroelectric generator having characteristics which are clearly defined in accordance with the level of water retained, passage flow rates, the inclination and the geometry of the outlet channel, width, height; this multiplication device in this example is constituted by a toothed wheel (10) having a large diameter and having inner teeth and a small pinion (13) which transmits the energy to the generator by means of a belt which is itself a multiplication device.

The multiplication device (10) is associated with a disc brake (11) which allows the wheel to be operated and stopped in a programmed and progressive manner - when the wheel is stopped, the water (with the exception of leaks) no longer passes through – the device thus allows the energy of tides to be used in both directions of ebb and flow.

The immobilisation of the wheel therefore allows the water level to be harnessed; the time required for the flow and the ebb of the water and the inclination of the blades (2) is therefore calculated in order to allow use in both directions.

The axle (6) which is constituted by a high-strength metal shaft, has a very significant function in terms of the retention and the precision of the assembly. This shaft (6) is assembled with the fixed part (4) by means of rollers (12), thus providing the best possible level of mechanical precision for the assembly.

The following Figures 3 to 8 provide other solutions or additions in accordance with other examples based on the same principle involving a moving part/fixed part.

According to the example of Figure 3 which comprises 16 blades, in order to harness the available amount of water to the greatest possible extent, the discs which support the blades may have a toothed outer form; since the blades are above the support, they use the entire available amount of water.

In this same example, blades are equipped with flaps C1 and C2 which are activated by means of pivoting rod and cam systems in order to act as a lift-type device for fish (when it is impossible to fit the steps required by the corresponding provisions). The fish always gather towards the water outlets when the outlet speeds allow, which is the case with this device; when the blade is in position P10, the flap C1 opens and serves as a scoop with the blade. As soon as it has left the water, a second flap C2 closes the top of the scoop and, in the position in which they move back into the water (position P4), the two flaps return to their original position, releasing the fish into the dam water, which allows them to continue their journey in an upstream direction.

In all cases, the downstream movement of the fish takes place through the wheel itself by means of the space between the blades and the natural flow rates of the water and this downstream movement occurs with no fatality of any kind.

Figure 4 illustrates various types of inclination of curved blades, the calculations will establish the most effective profiles and inclinations.

The variation in the flow rates of the turbine can be produced in two manners.

According to the example of Figure 5:
the rotating cylinder (1) comprises a plurality of sections, in this example there are 2; these sections can be mechanically isolated from each other, one of the sections being able to stop whilst the others rotate, which further reduces the passing flow rate, the water being stopped when in the stationary state, or the sections combine their forces by means of a conventional clutch engagement/disengagement system (for example, by means of magnetic keys) which are fitted on the contiguous crowns (5'), a

support (8) and rollers (9) are therefore associated with each crown (5') in the same manner as the crowns (5).

According to Figures 6 and 7:
the variation in the flow rates is brought about by multiform blades having movable parts.

Figure 6 is a cross-section of a blade whose different shapes are produced by means of a fixed part (17) and by means of articulated movable parts (18) (19) referred to as flaps.

These blades are assembled on the circular crown (5) which has a tubular shape and a rectangular cross-section in order to receive the control systems, hydraulic micro-jacks or electric motors.

These flaps rotate about an axis of rotation (20).

The outer flap (18) is articulated so as to conform to the outer shape of the channel which is also the outer shape of the crown (5).

The inner flap (19) is articulated so as to conform to the inner shape of the channel which is also the inner shape of the crown (5).

These flaps are guided and positioned, at the other end thereof, by means of hollow grooves (21) in the crown (5) for supporting the blades.

Figure 7 illustrates blades with movable parts which allow variation of the flow rates, this Figure relates to a wheel having 16 blades, that is to say, 16 gaps between two blades, that is to say, 16 spaces between two blades for a complete rotation of the wheel.

This Figure illustrates a quarter of the wheel, taken as a section through the blades, in a case where one space in two may be covered or not, the blades are therefore successively equipped either with the outer flap (18) or the inner flap (19).

The Figure illustrates:
- the flaps folded down on the fixed parts: position D

- the flaps in the open position: position E

In this manner, in position E, the space between two blades can no longer fill with water.

The isolation of a space, in this example, will reduce the flow rate by $1/16^{th}$ of its value, the flow rate will thus be able to be progressively reduced by $1/16^{th}$ as far as a reduction of $8/16^{ths}$, that is to say, half the nominal flow rate of the wheel.

- Using the multiform blade system, the flow rate will be able to be reduced progressively by $1/16^{th}$ and, by equipping all the blades according to Figure 6, this flow rate could be progressively reduced, if necessary, by $1/16^{th}$ as far as complete stoppage of the wheel.

The equipment of the wheel will be determined from case to case, in accordance with the objectives of anticipated flow rate and power levels and can start from provision of one gap between two blades up to 100% of the gaps.

Figure 8 illustrates a front view of a wheel having 16 blades, in which these blades are V-shaped; in this example, each blade is in a plane but these blades may also be formed as curved surfaces as in Figure 4; in this Figure, the water is not blocked in the stationary state, the assembly operates with priority being given to the dynamic and kinetic effects and the rotation speed will be higher, the calculations will determine the effectiveness of this solution which is similar to turbines having a vertical axle whilst remaining in completely different speed ranges; the rotation speed of the turbine remains directly linked to the water flow rate.

The blades are retained if necessary at three locations: two discs (5) and a disc (3) as in Figure 5.

In any case, the overall diameter of the wheel, owing to the position of the axle and the requirements in terms of the blades being introduced into the water, is in the order of 1.5 times the fall height increased by twice the height of the water outlet channel (which is the height of the blades), this height is a direct function of the retained flow rate.

The action on the blades in the channel benefits from a very large lever arm owing to the diameter of the wheel, which allows operation with the minimum of energy and a reduced speed.

The potential forces of the water levels and the kinetic energy of water/blade movements between A and B are used in the most effective manner at C (in Figure 1).

The geometric dimensions may be very variable: the overall diameter of the wheel, the width thereof, the height and the shape of the blades and the retention level of the water are directly linked to the operational parameters of the river or the water reservoirs, the fall heights being able to be very low (in the order of from 1m which is an economical limit for the intended use of this device) to heights of 4m or more. The only limitations of the device are imposed by the constraints in terms of mechanical strength and precision of the various materials used.

For the lowest heights, the channel (15) becomes insignificant.

In the example illustrated in Figures 1 and 2:
- the level H of water retention is 2m
- the height of the blades is 60cm
- the total height of the wheel is 5m
- the flow rate is in the order of $3.5m^3/sec$
- the net power produced at the outlet of the generator is in the order of 50KW.

Intended industrial application

The general production of the elements, including that of the blades, is very simple and economical owing to their shape.

The whole assembly can be completely assembled in situ.

The total height of the assembly and the energy produced are a function of the two parameters constituted by the two different assembled elements: the central fixed disc (water level) (4-8) and the blades (flow rates) (2), it is thus possible, by combining these two elements which can each comply with a production standard, to comply, using a standard assembly

(combination of two standards), with multiple variations of energy production which can lead to an industrialisation of the system and excellent control of the costs, as is the case with the other components of the assembly: multiplication device – generator.

The concept allows heavy constraints of the hydroelectric installations to be overcome. Following excavation, it allows the simple and rapid installation, in a few pre-assembled parts, of the hydroelectric generator which is constituted in this manner and which has well defined and guaranteed features, which opens up an entirely new range of equipment with the use of the lowest flow rates and gradients, of which little use is currently made, at low cost in terms of equipment and use.

This device is completely suitable for the development of micro-economies at a low cost, in the context of ecological and durable energy.

Environment

The water flow as well as the range of flow rates remain within the scope of the natural flows, the shape and distance between blades allowing living species to pass through with no fatalities or injury, thus responding to the concerns of anglers and ecological protection bodies by allowing the fish to move in a downstream direction; this device also allows the majority of objects carried by the current to pass through. It is therefore necessary to provide only wide-meshed protection grills for large objects.

The configurations remain within the visual aesthetics of traditional bladed wheels with no pollution other than that of noise of rotation in the water.